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Science and Technology Issues in the 115th Congress

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Summary

Science and technology (S&T) have a pervasive influence over a wide range of issues confronting the nation. Public and private research and development spur scientific and technological advancement. Such advances can drive economic growth, help address national priorities, and improve health and quality of life. The constantly changing nature and ubiquity of science and technology frequently create public policy issues of congressional interest.

The federal government supports scientific and technological advancement directly by funding and performing research and development and indirectly by creating and maintaining policies that encourage private sector efforts. Additionally, the federal government establishes and enforces regulatory frameworks governing many aspects of S&T activities.

This report briefly outlines an array of science and technology policy issues that may come before the 115th Congress. Given the rapid pace of S&T advancement and its importance in many diverse public policy issues, S&T-related issues not discussed in this report may come before the 115th Congress. The selected issues are grouped into 9 categories:

- Overarching S&T Policy Issues,
- Agriculture,
- Biomedical Research and Development,
- Defense,
- Energy,
- Environment and Natural Resources,
- Homeland Security,
- Information Technology,
- Physical and Material Sciences, and
- Space.

Each of these categories includes concise analysis of multiple policy issues. The material presented in this report should be viewed as illustrative rather than comprehensive. Each section identifies CRS reports, when available, and the appropriate CRS experts to contact for further information and analysis.

Contents

Contacts

Introduction

Science and technology (S&T) play an increasingly important role in our society. Advances in science and technology can help drive economic growth, improve human health, increase agricultural productivity, and meet national priorities.

Federal policies affect scientific and technological advancement on several levels. The federal government directly funds research and development (R&D) activities to achieve national goals or support national priorities, such as funding basic life science research through the National Institutes of Health (NIH) or developing new weapons systems in the Department of Defense (DOD). The federal government establishes and maintains the legal and regulatory framework that affects S&T activities in the private sector. Federal tax, trade, intellectual property, regulatory, and education policies can have large effects on private sector S&T activity.

This report serves as a brief introduction to many of the science and technology policy issues that may come before the 115th Congress. Each issue section provides background information and outlines selected policy issues that may be considered. Each issue includes a heading entitled "For Further Information" that provides the author's contact information and the titles of relevant CRS reports containing more detailed policy analysis and information.

Overarching S&T Policy Issues

Several issues of potential congressional interest apply to federal science and technology policy in general. This section begins with a brief introduction to the roles each branch of the federal government plays in S&T policymaking, then discusses overall federal funding of research and development. Additional sections address issues related to the America COMPETES Act; oversight of federally supported academic research; technology transfer; the adequacy of the science and engineering workforce; science, technology, engineering, and mathematics (STEM) education; and innovation-related tax policy.

Federal Science and Technology Policymaking Enterprise

The federal S&T policymaking enterprise is composed of an extensive and diverse array of stakeholders in the executive, legislative, and judicial branches. The enterprise fosters, among other things, the advancement of scientific and technical knowledge; STEM education; the application of S&T to achieve economic, national security, and other societal benefits; and the use of S&T to improve federal decisionmaking.

Federal responsibilities for S&T policymaking are highly decentralized. In addition to appropriating funding for S&T programs, Congress enacts laws to establish, refine, and eliminate programs, policies, regulations, regulatory agencies, and regulatory processes that rely on S&T data and analysis. However, Congress's authorities related to S&T policymaking are diffuse. Many House and Senate committees have jurisdiction over important elements of S&T policy. In addition, there are dozens of informal congressional caucuses in areas of S&T policy such as research and development, specific S&T disciplines, and STEM education.

The President formulates annual budgets, policies, and programs for consideration by Congress; issues executive orders and directives; and directs the executive branch departments and agencies responsible for implementing S&T policies and programs. The Office of Science and Technology Policy, in the Executive Office of the President, advises the President and other Administration officials on S&T issues.

Executive agency responsibilities for S&T policymaking are also diffuse. Some agencies have broad S&T responsibilities (e.g., the National Science Foundation). Others use S&T to meet a specific federal mission (e.g., defense, energy, health, space). Regulatory agencies have S&T responsibilities in areas such as nuclear energy, food and drug safety, and environmental protection.

Federal court cases and decisions often affect U.S. S&T policy. Decisions can have an impact on the development of S&T (e.g., decisions regarding the U.S. patent system); S&T-intensive industries (e.g., the break-up of AT&T in the 1980s); and the admissibility of S&T-related evidence (e.g., DNA evidence).

For Further Information

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CRS Report R43935, *Office of Science and Technology Policy (OSTP): History and Overview*, by (name redacted) and (name redacted)

Federal Funding for Research and Development

The federal government has long supported the advancement of scientific knowledge and technological development through investments in R&D. Federal R&D funding seeks to address a broad range of national interests, including national defense, health, safety, the environment, and energy security; advance knowledge generally; develop the scientific and engineering workforce; and strengthen U.S. innovation and competitiveness. The federal government has played an important role in supporting R&D efforts which have led to scientific breakthroughs and new technologies, from jet aircraft and the Internet to communications satellites and defenses against disease.

Between FY2009 and FY2016, federal R&D funding fell from $147.3 billion to $146.1 billion, a reduction of $1.2 billion (0.8% in current dollars, 11.1% in constant dollars); funding has rebounded from a period low of $130.3 billion in FY2013. The decline was a reversal of sustained growth in federal R&D funding for more than half a century, and has stirred debate about the potential long-term effects on U.S. technological leadership, innovation, competitiveness, economic growth, and job creation. Concerns about reductions in federal R&D funding have been exacerbated by increases in the R&D investments of other nations (China, in particular); globalization of R&D and manufacturing activities; and trade deficits in advanced technology products, an area in which the United States previously ran trade surpluses. At the same time, some Members of Congress have expressed concerns about the level of federal funding in light of the current federal fiscal condition. In addition, R&D funding decisions may be affected by differing perspectives on the appropriate role of the federal government in advancing science and technology.

As Congress undertakes the appropriations process it faces two overarching issues: (1) the direction in which the federal R&D investment will move in the context of increased pressure on discretionary spending and (2) how available funding will be prioritized and allocated. Low or negative growth in the overall R&D investment may require movement of resources across disciplines, programs, or agencies to address priorities. Congress will play a central role in defining the nation's R&D priorities as it makes decisions with respect to the size and distribution of aggregate, agency, and programmatic R&D funding.

For Further Information

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CRS Report R44516, *Federal Research and Development Funding: FY2017*, coordinated by (name redacted)

CRS Report R41951, *An Analysis of Efforts to Double Federal Funding for Physical Sciences and Engineering Research*, by (name redacted)

America COMPETES Act Reauthorization

The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act (P.L. 110-69) was enacted in 2007. The act, a response to concerns about U.S. competitiveness, authorized certain federal research, education, and innovation-related activities. In 2010, Congress passed the America COMPETES Reauthorization Act of 2010 (P.L. 111-358), extending and modifying certain provisions of the 2007 law, as well as establishing new provisions. Congressional appropriations have generally been below authorized levels, and the specific authorizations of appropriations in the 2010 act have expired. Following previous reauthorization efforts that inspired debate about such topics as the scientific peer review process, certain provisions of these acts were reauthorized and modified as part of the American Innovation and Competitiveness Act (AICA, P.L. 114-329), enacted at the end of the 114th Congress. The 115th Congress may consider additional provisions from the COMPETES acts that were not addressed through the AICA, such as expired authorizations of appropriations for the National Science Foundation (NSF) and the National Institute of Standards and Technology (NIST).

The COMPETES acts were originally enacted to address concerns that the United States could lose its advantage in scientific and technological innovation. Economists have asserted that economic, security, and social benefits accrue preferentially to nations that lead in scientific and technological advancement and commercialization. Some analysts have suggested that historical U.S. leadership in these areas is slipping, and in particular, some stakeholders have questioned the adequacy of federal funding for physical sciences and engineering research and the domestic production of scientists and engineers.

The COMPETES acts were designed to respond, in part, to these challenges by authorizing increased funding for the National Institute of Standards and Technology, National Science Foundation, and Department of Energy's Office of Science. Together, the acts also authorized certain federal STEM education activities, the Advanced Research Projects Agency-Energy (ARPA-E), and prize competitions at federal agencies, among other provisions.

Those who have expressed opposition to aspects of the COMPETES acts have done so from several perspectives. Some critics question the existence of a STEM labor shortage and thus the need for programs aimed at increasing the number of STEM workers. Other critics agree with the assertion of a shortage, but question whether the federal government should address it, believing that the market will make the necessary corrections to meet the demand. With respect to U.S. competitiveness, some analysts prefer alternative approaches to those proposed in the COMPETES acts, such as research tax credits or reducing regulatory costs. Other analysts object to the financial cost associated with the COMPETES acts, given concern about the federal budget deficit and debt.

For Further Information

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CRS Report R44345, *Efforts to Reauthorize the America COMPETES Act: In Brief*, by (name redacted)

Regulations for Federally Funded Research at Academic Institutions

For decades, the federal government and academic research institutions have been partners in supporting American innovation, competitiveness, and economic growth. The federal government is the largest source of academic research and development (R&D) funding in the United States, providing funds through more than two dozen federal agencies, with the National Institutes of Health (NIH) and the National Science Foundation (NSF) providing the largest portions of federal R&D funding to U.S. colleges and universities.

As part of oversight of federal funding for academic research, Congress and federal agencies have established requirements through statutes, regulations, and guidance documents that U.S. universities and other research institutions must comply with when applying for, receiving, and reporting on the results of federal research grants. Such requirements seek to ensure transparency and effectiveness of federal funds, while helping to prevent waste, fraud, and abuse. Academic research institutions broadly recognize the need for federal regulations but have raised concerns about unintended consequences, such as reducing research productivity and the return on federal investments. Areas of concern frequently cited by researchers and academic administrators include the amount of time spent completing administrative tasks compared to conducting research; the increasing number, and lack of harmonization, of requirements across federal funding agencies; and the adequacy of stakeholder engagement in the review and modification of federal regulations.

Legislation was enacted in the 114th Congress that addressed some of the concerns, including the 21st Century Cures Act (P.L. 114-255), the American Innovation and Competitiveness Act (AICA, P.L. 114-329), and the National Defense Authorization Act for Fiscal Year 2017 (NDAA, P.L. 114-328). Enacted provisions addressed issues at specific agencies, including conflicts of interest disclosure, financial reporting, and subrecipient monitoring. Enacted provisions also addressed cross-agency efforts by directing the establishment of an advisory committee (Research Policy Board) with federal and non-federal stakeholders, as well as an interagency working group on federal research regulations.

Congressional oversight may be an important part of monitoring the progress of implementing the provisions enacted in the 114th Congress in a holistic way and evaluating their overall effectiveness. Further, Congress may broadly consider the appropriate balance between supporting the nation's academic research enterprise through efforts to streamline regulations and maintaining effective mechanisms for oversight, transparency, and accountability.

For Further Information

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CRS Report R44774, *Federally Funded Academic Research Requirements: Background and Issues in Brief*, by (name redacted) and (name redacted)

Technology Transfer from Federal Laboratories

Every year, approximately one-third of the federal government's R&D spending is obligated to federal laboratories, including federally funded research and development centers, in support of agency mission requirements. The technology and expertise generated by federal laboratories may have applications beyond the immediate goals or intent of the original R&D. Over the years, Congress has established various mechanisms—primarily through the Stevenson-Wydler Technology Innovation Act of 1980 and subsequent legislation—to facilitate the transfer of technology and research generated from federal laboratories to the private sector where it can be further developed and commercialized.

Technology transfer from federal laboratories can occur in many forms. In some instances, it can occur through formal partnerships and joint research activities between federal laboratories and private firms, including through cooperative research and development agreements or CRADAs. In other cases, it can occur when the legal rights to a government-owned patent are licensed to a private firm.

Congressional interest in promoting the transfer of technology from federal laboratories is based on an interest in meeting social needs and promoting economic growth to enhance the nation's welfare and security. Economic benefits of a technology accrue when a product, process, or service is brought to the marketplace where it can be sold or used to increase productivity. In addition, cooperation with the private sector provides a means for federal scientists and engineers to obtain technical information from the private sector, which in some instances is more advanced than the federal government.

Despite the efforts of federal agencies and Congress to increase the effectiveness of technology transfer from federal laboratories to the private sector, the use of federal technologies has remained restrained. Critics argue that working with federal laboratories continues to be difficult and time-consuming. Proponents of current efforts assert that federal laboratories are open to interested parties, but it remains up to the private sector to use them. At issue is whether additional legislative initiatives and federal incentives are needed to encourage increased technology transfer from federal laboratories, or if the available resources are sufficient.

Further Information

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CRS Report R44629, *Federally Funded Research and Development Centers (FFRDCs): Background and Issues for Congress*, by (name redacted)

Adequacy of the U.S. Science and Engineering Workforce

The adequacy of the U.S. science and engineering (S&E) workforce has been an ongoing concern of Congress for more than 60 years. Scientists and engineers are widely believed to be essential to U.S. technological leadership, innovation, manufacturing, and services, and thus vital to U.S. economic strength, national defense, and other societal needs. Congress has enacted many programs to support the education and development of scientists and engineers. Congress has also undertaken broad efforts to improve science, technology, engineering, and math (STEM) skills to prepare a greater number of students to pursue S&E degrees. In addition, some policymakers have sought to increase the number of foreign scientists and engineers working in the United States through changes in visa and immigration policies.

Most experts agree that there is no authoritative definition of which occupations comprise the S&E workforce. Rather, the selection of occupations included in any particular analysis of the

S&E workforce may vary depending on the objective of the analysis. The policy debate about the adequacy of the U.S. S&E workforce has focused largely on professional-level computer occupations, mathematical occupations, engineers, and physical scientists. Accordingly, much of the analytical focus has been on these occupations. However, some analyses may use a definition that includes some or all of these occupations, as well as life scientists, S&E managers, S&E technicians, social scientists, and related occupations. Among the key indicators used by labor economists to assess occupational labor shortages are employment growth, wage growth, and unemployment rates.

Many policymakers, business leaders, academicians, S&E professional society analysts, economists, and others hold differing views with respect to the adequacy of the S&E workforce and related policy issues. These issues include the question of the existence of a shortage of scientists and engineers in the United States, what the nature of any such shortage might be (e.g., too few people with S&E degrees, mismatches between skills and needs), and whether the federal government should undertake policy interventions or rely upon market forces to resolve any shortages in this labor market.

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Science, Technology, Engineering, and Mathematics Education

The term "STEM education" refers to teaching and learning in the fields of science, technology, engineering, and mathematics. Policymakers have had an enduring interest in STEM education. Popular opinion generally holds that U.S. students perform poorly in STEM subjects—especially when compared to students in certain foreign education systems—but the data paint a complicated picture. Over time, U.S. students appear to have made gains in some areas but may be perceived as falling behind in others.

Previous estimates of the federal STEM education effort found a range of between 105 and 254 STEM education activities at 13 to 15 federal agencies. However, as tracked over time by the Obama Administration, the number of federal STEM education activities appears to have dropped by half, from 254 to 125, between FY2010 and FY2016. While total federal funding for STEM education stayed about the same during this period—close to $3 billion annually—the effects of these changes on the federal STEM education effort overall are unknown.

The national conversation about STEM education frequently develops from concerns about the U.S. science and engineering workforce. Some observers assert that the United States faces a shortage of STEM workers; others dispute this claim. Many proponents argue that a general increase in STEM abilities among the U.S. workforce could benefit the nation regardless. On the other hand, some scholars oppose the use of education policy to increase the supply of STEM workers, either because they perceive such policies as overemphasizing the economic outcomes of education at the expense of other values (e.g., personal development or citizenship) or because they perceive the labor market as the more efficient mechanism for dealing with these issues.

Opinions differ as well on the appropriate scope, scale, and emphasis of federal STEM education policy. Some observers prefer policies aimed at lifting the STEM achievement of all students—such as teacher or faculty professional development; or changes in curriculum, standards, or pedagogy. Others emphasize policies designed to meet specific needs—such as scholarships for the "best and brightest," federal workforce training, or programs for underrepresented groups.

For Further Information

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Tax Incentives for Technological Innovation

The 115th Congress may consider new federal policies to promote technological innovation. Among the concerns fueling this interest is what some view as inadequate growth in domestic high-paying jobs in a range of industries in recent years. Three pathways to accelerating growth in these jobs are (1) faster rates of entrepreneurial business formation, (2) increased business investment in domestic R&D, and (3) greater domestic production of products and services derived from that research.

One way Congress can influence the rate of high-wage job creation is tax incentives for investment in innovation. Under current federal tax law, three provisions directly affect entrepreneurial business formation and business investment in R&D: (1) an expensing allowance for research expenditures under Section 174 of the tax code, (2) a non-refundable tax credit for increases in research expenditures above a base amount under Section 41, and (3) a full exclusion for capital gains from the sale or exchange of qualified small business stock held by the original investor for five or more years under Section 1202.

The tax credit and expensing allowance encourage companies to invest more in qualified research than they otherwise would by lowering the cost of capital for that research and boosting cash flow. Some argue that the current credit's incentive effect is too weak to increase business R&D investment to optimal levels. In their view, the credit's design has certain flaws that lead to uneven and arbitrary incentive effects and make it difficult for small startup companies to use the full amount of the credit in years when they have net operating losses. The credit was permanently extended at the end of 2015, while the expensing allowance has been a permanent tax provision since 1954.

Under Section 1202, a non-corporate investor may exclude 100% of any capital gain on qualified small business stock acquired after September 27, 2010. The exclusion is intended to boost equity investment in small startup firms in designated industries (particularly manufacturing) by reducing the tax burden on the returns to that investment relative to after-tax returns on alternative investments.

Recent research indicates that young startup firms account for most net U.S. job growth over time, but that access to capital remains a significant barrier to the formation of such firms. It is unclear what share of U.S. high-paying jobs are accounted for by small firms, but small entrepreneurial firms that survive and grow into large, successful companies can be a prolific source of such jobs. Industries that intensively use intellectual property (IP) directly and indirectly (through supply chains) accounted for 30% of U.S. jobs in 2014, and workers in those industries had average weekly earnings that were 46% larger than the average weekly earnings of workers in non-IP intensive industries in the same year.

The 115th Congress may consider whether new initiatives are needed to increase the rate of growth in domestic high-paying jobs. One option that might be explored is the creation of a tax incentive known as a patent or innovation box. Such an incentive lowers the tax burden on the income earned from the commercial use of qualified intellectual property, such as trademarks or patents. Depending on its design, a patent box could give companies investing in innovation a stronger incentive to expand their investment in U.S. R&D and production activities. Potential drawbacks to such a subsidy include its budgetary cost and the difficulty of justifying it on economic grounds.

For Further Information

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CRS Report RL31181, *Research Tax Credit: Current Law and Policy Issues for the 114th Congress*, by (name redacted)

CRS Report R44522, *A Patent/Innovation Box as a Tax Incentive for Domestic Research and Development*, by (name redacted)

Agriculture

The federal government supports billions of dollars of agricultural research annually. The 115th Congress is likely to face issues related to funding this research and specific issues arising from advances in agricultural biotechnology and the use of antibiotics in food-producing animals.

Agricultural Research

Public investment in agricultural research has been linked to productivity gains, and subsequently to increased agricultural and economic growth. The U.S. Department of Agriculture's (USDA's) Research, Education, and Economics (REE) mission area has the primary federal responsibility of advancing scientific knowledge for agriculture. USDA-funded research spans the biological, physical, and social sciences related broadly to agriculture, food, and natural resources.

USDA conducts its own research and administers federal funding to states and local partners primarily through formula funds and competitive grants. The outcomes are delivered through academic and applied research findings, statistical publications, cooperative extension, and higher education.

USDA's research program is funded with nearly $2.9 billion per year of discretionary funding and about $120 million of mandatory funding. Congress traditionally reauthorizes and revises agricultural research programs in the five-year farm bill.

Since the 2014 farm bill (P.L. 113-79) expires on September 30, 2018, the next farm bill is expected to be debated in the 115th Congress. Some agricultural research programs will face reauthorization. Various agricultural, academic, and other interests may pursue changes to the scope or focus of those programs or request additional funding.

For Further Information

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CRS Report R40819, *Agricultural Research: Background and Issues*, by (name redacted)

CRS In Focus IF10187, *The 2014 Farm Bill (Agricultural Act of 2014)*, by (name redacted) and (name redacted)

Agricultural Biotechnology

The 115th Congress might address issues regarding bioengineered foods labeling, or foods containing bioengineered ingredients, regulatory changes governing the introduction of genetically engineered (GE) plants and animals into the environment, and recent technical innovations that could raise new regulatory issues for agricultural biotechnology.

Currently, labeling GE food products is not required. The 114th Congress approved a bill (P.L. 114-216) in June 2016 that will establish a "national bioengineered food disclosure standard." The U.S. Department of Agriculture (USDA) has two years to implement the labeling law. Food

manufacturers can adopt either text, a symbol, or an electronic/digital link for identifying bioengineered foods. The labeling bill includes foods made through conventional genetic engineering technology as well as newer techniques in the definition of bioengineered foods.

P.L. 114-216 also requires USDA to conduct a study within a year of enactment that identifies potential technological factors that could affect consumer access to bioengineered food disclosure through electronic or digital methods such as QR codes on food products read by smart phones. Concerns have been raised that such digital methods of disclosure could have differential impacts on those without cell phones (e.g., the elderly, low-income families) and those without access to high-speed broadband. The required study is to specifically address the availability of wireless or cellular networks, availability of landline telephones in stores, and particular factors that might affect small retailers and rural retailers as well as consumers.

The development over the past several years of new technologies to genetically engineer plants, in particular novel gene-editing technologies, has raised new regulatory issues. USDA currently regulates GE plants under the Plant Protection Act (PPA; 7 U.S.C. §770). However, USDA has stated that newer technologies may fall outside the purview of the PPA and thus the Department might have no regulatory jurisdiction over plants genetically engineered using these new technologies. This has raised important questions about how such genetically engineered plants are to be regulated as they are introduced. As genetically engineered plant varieties created by these techniques become more common, and as the public becomes more aware that these varieties are not regulated under the PPA, Congress might choose to revisit the 1986 framework that governs U.S. biotechnology regulation.

For Further Information

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CRS In Focus IF10376, *Labeling Genetically Engineered Foods: Current Legislation*, by (name re dacted)

CRS Report R43518, *Genetically Engineered Salmon*, by (name redacted) and (name redacted)

CRS Report RL32809, *Agricultural Biotechnology: Background, Regulation, and Policy Issues*, by (name redacted)

CRS Report RL33334, *Biotechnology in Animal Agriculture: Status and Current Issues*, by (name redacted)

CRS Report R43100, *Unapproved Genetically Modified Wheat Discovered in Oregon and Montana: Status and Implications*, by (name redacted)

Antibiotic Use in Food Producing Animals

The use of medically important antibiotics in food producing animals may interest the 115th Congress. Past Congresses have introduced legislation (in the 114th Congress, e.g., H.R. 1552 and S. 621) to restrict the use of some antibiotics in animals. In 2014, the Obama Administration launched the Combating Antimicrobial Resistant Bacteria (CARB) initiative, a cross-departmental effort to preserve effective antibiotics for critical public and animal health needs.

The U.S. Food and Drug Administration (FDA) evaluates human and animal drugs for safety and effectiveness under the Federal Food, Drug, and Cosmetic Act (FFDCA, 21 U.S.C. 301 et seq.). FDA is concerned about public health effects from certain antibiotic uses in food animals. According to FDA, foods of animal origin may carry pathogens that cause foodborne infections,

and antibiotic use in animals that produce these foods may render the infections untreatable due to antibiotic resistance.

In response to concern about antibiotic resistance, FDA issued guidance on the judicious use of antibiotics in animals. FDA finalized Guidance for Industry #213 in December 2013, giving animal drug sponsors three years to withdraw antibiotics for production uses (i.e., growth promotion or feed efficiency) and to update evidence for treatment and preventive or control uses. Guidance #213 became effective January 1, 2017. After this date, medically important antibiotics may only be used when necessary to treat and prevent diseases.

In June 2015, FDA finalized rules (80 *Federal Register* 31708) for the Veterinary Feed Directive (VFD)—prescriptions for animal drugs used in feed—that builds on FDA policy on judicious antibiotic use. Since January 1, 2017, all medically important antibiotics used in feed require a VFD. This requires that producers have an established veterinarian-client-patient relationship (VCPR) as defined in state regulations, or federal VFD regulations for states without VCPR requirements. A valid VCPR requires licensed veterinarians to be familiar with clients' farm and animals. Producers will now need prescriptions for non-feed antibiotics that previously were available over-the-counter. Finally, in May 2016, FDA issued a final rule (81 *Federal Register* 29129) to expand its reporting on the distribution and use of antibiotics.

Related to antibiotic resistance efforts, at the end of 2014, the U.S. Department of Agriculture (USDA) released its Antimicrobial Resistance Action Plan, with initiatives to develop research and collect information on antibiotic use in animals. USDA also requested additional funds in FY2017 for its antibiotic resistance activities.

For Further Information

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CRS In Focus IF10190, *Antibiotic Use in Food Animals: FDA's Current Activities*, by (name redacted) and (name redacted)

Biomedical Research and Development

Advances in science and technology related to biomedical research and development underpin improvements in human health and quality of life. Some of the biomedical R&D issues that the 115th Congress may face include those related to the budget and oversight of the National Institutes of Health, the role the Food and Drug Administration in approving new medicines and laboratory tests, and advances in precision medicine and genomic editing.

National Institutes of Health: Budget and the 21st Century Cures Act

The National Institutes of Health (NIH) is the lead federal agency conducting and supporting biomedical research. The agency's budget of about $31.5 billion funds basic, clinical, and translational research in NIH's laboratories as well as in research institutions nationwide. The extramural research program (83% of the NIH budget) provides grants, contracts, and training awards to support over 30,000 individuals at more than 2,500 universities, academic health centers, and research facilities. Over a five-year period, FY1999-FY2003, the NIH budget doubled in current dollars, but since that time constraints on discretionary spending have decreased budget growth below the rate of inflation. In constant dollars, NIH funding peaked in

FY2003 (not counting FY2009 stimulus funding); FY2016 NIH funding was 19% below the FY2003 peak.

The 21st Century Cures Act (P.L. 114-255), signed by President Obama on December 13, 2016, authorizes $4.8 billion for NIH over a 10-year period (FY2017-FY2026), averaging slightly under a half billion per year, or a 1.5% increase per year for the agency. However, the funding is not guaranteed and must be appropriated each year in subsequent appropriations acts. In addition, the funds may only be used for four specified projects: (1) the Precision Medicine Initiative, $1.455 billion for FY2017-FY2026; (2) the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, $1.511 billion for FY2017-FY2026; (3) cancer research, $1.8 billion for FY2017- FY2023; and (4) regenerative medicine using adult stem cells, $30 million for FY2017-FY2020. The new law makes a number of other policy changes, such as modifying the NIH strategic planning process, altering the agency's reporting requirements, and reducing the administrative burden for researchers, among other things.

For Further Information

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CRS Report R41705, *The National Institutes of Health (NIH): Background and Congressional Issues*, by (name redacted)

CRS Report R43341, *NIH Funding: FY1994-FY2017*, by (name redacted)

CRS Report R44720, *The 21st Century Cures Act (Division A of P.L. 114-255)*, coordinated by (name redacted)

CRS Report R44505, *Public Health Service Agencies: Overview and Funding (FY2015-FY2017)*, coordinated by (name redacted) and (name redacted)

The Food and Drug Administration (FDA) and the 21st Century Cures Act

The Food and Drug Administration (FDA) regulates the safety of foods (including dietary supplements), cosmetics, and radiation-emitting products; the safety and effectiveness of drugs, biologics (e.g., vaccines), and medical devices; as well as public health aspects of tobacco products. In the 114th Congress, both the House and Senate introduced bipartisan legislation to support medical innovation, primarily through reforms to the NIH and changes to the drug, biologic, and device approval pathways at the FDA. On December 13, 2016, the 21st Century Cures Act (P.L. 114-255) was signed into law.

Among other things, Division A of the act contains provisions to accelerate development and review of certain medical products; for example, by directing the Secretary to facilitate an "efficient development program for, and expedite review of" eligible regenerative advanced therapies (including cell therapy, therapeutic tissue engineering products, human cell and tissue products); creating a limited population pathway for antibacterial drugs to treat a serious or life-threatening infection in a limited population of patients with unmet needs; and establishing a priority review program to incentivize development of treatments for agents that present a national security threat.

To help fund the activities and programs authorized in 21st Century Cures Act, the law creates an FDA Innovation Account, to which a total of $500 million is authorized to be transferred over a nine-year period (FY2017-FY2025). Release of funds from the FDA Account is controlled

through the annual appropriations process. The 115th Congress will likely begin to see implementation of these programs and activities.

For Further Information

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CRS Report R44576, *The Food and Drug Administration (FDA) Budget: Fact Sheet*, by (name redacted) and (name redacted)

CRS Report R44720, *The 21st Century Cures Act (Division A of P.L. 114-255)*, coordinated by (name redacted)

Oversight of Laboratory-Developed Tests (LDTs)

In vitro diagnostic (IVD) devices provide information that is used by clinicians and patients to make health care decisions. IVDs are used in laboratory analysis of human samples and include commercial test products and instruments used in testing, among other things. Laboratory-developed tests (LDTs) are a class of IVD that is manufactured, including being developed and validated, and offered, within a single laboratory. LDTs may sometimes be referred to as "home-brew tests." Genetic tests are a type of diagnostic test that analyzes various aspects of an individual's genetic material (DNA, RNA, chromosomes, and genes). Most genetic tests are LDTs.

The regulation of LDTs has been the subject of debate over the past decade. The Food and Drug Administration (FDA) has traditionally exercised enforcement discretion over LDT regulation. This means that most LDTs, and most genetic tests, have not been subject to FDA premarket review and therefore have not received FDA clearance or approval for marketing. Given the growing use of LDTs and genetic tests in clinical medicine, the FDA has in recent years revisited whether, and the extent to which, LDTs should be regulated.

On July 31, 2014, the FDA notified the Senate Committee on Health, Education, Labor and Pensions and the House Committee on Energy and Commerce that it would be issuing draft guidance on LDT regulation. On October 3, 2014, the agency published a notice in the *Federal Register* announcing the availability of the guidance documents and requesting comments within 120 days to ensure their consideration in the development of final guidance. However, on November 18, 2016, the FDA indicated that it would postpone finalization of the draft guidance until the new Administration is in place.

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CRS Report R43438, *Regulation of Clinical Tests: In Vitro Diagnostic (IVD) Devices, Laboratory Developed Tests (LDTs), and Genetic Tests*, by (name redacted) and (name redacted)

CRS Report RL33832, *Genetic Testing: Background and Policy Issues*, by (name redacted)

Precision Medicine Initiative (PMI)

On February 25, 2016, the White House hosted a Precision Medicine Initiative (PMI) Summit to mark the one year anniversary of the initiative's launch, first announced in the 2015 State of the Union address. The mission of the PMI is "[t]o enable a new era of medicine through research, technology, and policies that empower patients, researchers, and providers to work together

toward development of individualized care." The PMI primarily involves three federal agencies—the National Institutes of Health (NIH), the Food and Drug Administration (FDA), and the Office of the National Coordinator for Health Information Technology (ONC)—although other federal agencies have collaborated on and contributed to the effort. Precision medicine, also called personalized medicine, involves providing health care to an individual patient based on their unique characteristics, such as a genetic profile.

NIH has awarded multiple grants to begin building an extensive biobank, develop health care provider organizations (HPOs), and develop recruitment strategies for a million-person national research cohort program, now called the All of Us Research Program; NIH expects to begin enrolling participants in FY2017. To ensure the opportunity for participation of underserved individuals, NIH and the Health Resources and Services Administration (HRSA) awarded funding for a pilot program that is to determine infrastructure needs for health centers to serve as HPOs. In addition, FDA has developed *precisionFDA* to facilitate data sharing and validation of new genomic assays in precision medicine.

The 115th Congress may be interested in policies that support ongoing or modified investments in precision medicine. In FY2016, NIH received $200 million for the PMI: $70 million for the National Cancer Institute and $130 million for the Common Fund for the research cohort. FDA received $2.392 million, and ONC did not receive funding. The FY2017 President's budget requested a total of $309 million for the PMI: $4 million to FDA, $5 million to ONC, and the remaining $300 million to NIH. Pursuant to the authorizations of appropriations in the 21st Century Cures Act (P.L. 114-255), NIH received $40 million—in additional appropriations—for the PMI via the second FY2017 Continuing Resolution (P.L. 114-254), which provides funding through April 28, 2017.

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CRS Insight IN10227, *The Precision Medicine Initiative*, by (name redacted) and (name reda cted)

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CRS Report R44026, *Genomic Data and Privacy: Background and Relevant Law*, coordinated by (name redacted)

CRISPR: Advanced Genome Editing

Researchers have long been searching for a reliable and simple way to make targeted changes to the genetic material of humans, animals, plants, and microorganisms. A new gene editing tool known as CRISPR offers the potential for substantial improvement over previous methods in terms of ease of use, ubiquity, and cost. Some scientists believe CRISPR could lead to advances across a broad range of areas—from medicine and public health to agriculture and the environment. Additionally, CRISPR could lead to the development of products previously viewed as not feasible (e.g., the development of pig organs for human transplant). Potential advances offered by CRISPR, however, have also raised concerns about the ethics of some applications; associated health and safety risks; and the adequacy of the current regulatory framework to mitigate these health and safety risks. Both the potential opportunities and risks associated with CRISPR may be of interest in the 115th Congress.

For example, CRISPR-related approaches are being considered by some researchers to reduce or eliminate Zika virus and malaria. Effective reduction or elimination of the mosquito that serves as the primary vector for the transmission of Zika or malaria could save lives and substantially reduce costs. However, a 2016 report from the National Academy of Sciences indicates that existing mechanisms may be inadequate to assess the potential immediate and long-term environmental and public health consequences associated with the use of the technology.

Additionally, in April 2015, and again more recently in April 2016, Chinese scientists published results of experiments that attempted to modify the genetic makeup of nonviable human embryos using CRISPR. While federal funds currently cannot be used for research involving human embryos, the Chinese study has sparked ethical debates about the use of the technology in human embryos or to make permanent heritable changes to the genome. Some researchers and others have called for the establishment of international norms and the harmonization of regulations for the use of genome editing technologies.

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CRS Insight IN10610, *CRISPR: A Revolutionary Tool for Editing the Code of Life?*, by (name redacted) and (name redacted)

Microbial Pathogens in the Laboratory: Safety and Security

In addition to its general oversight of workplace safety, the federal government addresses the safety of laboratory personnel who work with infectious microorganisms through guidance such as Biosafety in Microbiological and Biomedical Laboratories (BMBL), published by the Department of Health and Human Services Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH). BMBL sets "Biosafety Levels" for work with the highest-risk pathogens. BMBL guidance is often adopted as a requirement. For example, BMBL compliance is required of federal grant recipients.

Biosecurity requirements, to protect the public from intentional and unintentional releases of pathogens, were first mandated by Congress in 1996, and expanded through subsequent reauthorizations. The Federal Select Agent Program, administered jointly by CDC and the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), oversees the possession of "select agents," certain biological pathogens and toxins with the potential to cause serious harm to public, animal, or plant health. All U.S. laboratory facilities—including those at government agencies, universities, research institutions, and commercial entities—that possess, use, or transfer select agents must register with the program and adhere to specified best practices. All persons given access to select agents must undergo background investigations conducted by the Federal Bureau of Investigation (FBI).

Several incidents involving the mishandling of select agents in federal laboratories occurred in recent years. Samples of decades-old but viable smallpox virus were found in an FDA laboratory on an NIH campus. Laboratories at CDC, one of the select agent regulatory agencies, had incidents involving the anthrax agent, a virulent avian influenza virus, and Ebola virus. A Department of Defense laboratory inadvertently distributed viable instead of killed samples of the anthrax organism. Each incident was attributed, at least in part, to lapses in protocol or some other form of human error. Several incident reports have recommended improvements in the

"culture of safety" in laboratories, standardized microbial handling practices, and better incident reporting, among other measures.

The authorizations of appropriations for the Select Agent Program (7 U.S.C. 8401-8402 and 42 U.S.C. 262a) expired in 2007. Congress has continued to fund ongoing implementation and enforcement. The 115th Congress may revisit program authority or regulations in light of recent incidents to determine whether current safety and security measures are adequate, as well as whether they allow important research on these pathogens to proceed.

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Defense

Science and technology play an important role in national defense. The Department of Defense (DOD) relies on a robust research and development effort to develop new military systems and improve existing systems. Issues that may come before the 115th Congress regarding the DOD's S&T activities include budgetary concerns and the effectiveness of programs to transition R&D results into fielded products.

Department of Defense Research and Development

The Department of Defense spends over $60 billion per year on research, development, testing, and evaluation (RDT&E). Roughly 80-85% of this is spent on the design, development, and testing of specific military systems. Examples of such systems include large integrated combat platforms such as aircraft carriers, fighter jets, and tanks, among others. They also include much smaller systems such as blast gauge sensors worn by individual soldiers. The other 15-20% of the RDT&E funding is spent on what is referred to as DOD's Science and Technology Program. The S&T Program includes activities ranging from basic science to demonstrations of new technologies in the field. The goal of DOD's RDT&E spending is to provide the knowledge and technological advances necessary to maintain U.S. military superiority.

DOD's RDT&E budget contains close to 1,000 individual line items. Congress provides oversight of the program, making adjustments to the amount of funding requested for any number of line items. These changes are based on considerations such as whether the department has adequately justified the expenditure or the need to accommodate larger budgetary adjustments.

RDT&E priorities and focus, including those of the S&T portion, do not change radically from year to year, though a few fundamental policy-related concerns regularly attract congressional attention. These include ensuring that S&T, particularly basic research, receives sufficient funding to support next generation capabilities; seeking ways to speed the transition of technology from the laboratory to the field; and ensuring an adequate supply of S&T personnel. Additionally, the impact of budgetary constraints, including continuing resolutions, on RDT&E may be of interest to the 115th Congress. Specifically, senior DOD officials have been describing the need to develop and implement a third offset strategy—a strategy aimed at identifying new and innovative ways to maintain the dominance of U.S. military capabilities into the future—which would likely require increased investment in RDT&E.

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Energy

The science and technology related-energy issues that may come before the 115th Congress include those related to reprocessing spent nuclear fuel, advances in nuclear energy technology, and the development of biofuels and of ocean energy technology.

Reprocessing of Spent Nuclear Fuel

Spent fuel from commercial nuclear reactors contains most of the original uranium that was used to make the fuel, along with plutonium and highly radioactive lighter isotopes produced during reactor operations. A fundamental issue in nuclear policy is whether spent fuel should be "reprocessed" or "recycled" to extract plutonium and uranium for new reactor fuel, or directly disposed of without reprocessing. Proponents of nuclear power point out that spent fuel still contains substantial energy that reprocessing could recover. However, reprocessed plutonium can also be used in nuclear weapons, so critics of reprocessing contend that federal support for the technology could undermine U.S. nuclear weapons nonproliferation policies.

In the 1950s and 1960s, the federal government expected that all commercial spent fuel would be reprocessed, using "breeder reactors" that would convert uranium into enough plutonium to fuel additional commercial breeder reactors.

Increased concern about weapons proliferation in the 1970s and the slower-than-projected growth of nuclear power prompted President Carter to halt commercial reprocessing efforts in 1977, along with a federal demonstration breeder project. President Reagan restarted the breeder demonstration project, but Congress halted project funding in 1983 while continuing to fund breeder-related research and development by the Department of Energy (DOE). Under President Clinton, research on producing nuclear energy through reprocessing was largely halted, although some work on the technology continued for waste management purposes.

The George W. Bush Administration renewed federal support for reprocessing, proposing to complete a pilot plant by the early 2020s. The Obama Administration halted plans for the pilot plant and redirected DOE's Fuel Cycle Research and Development Program toward development of technology options for a wide range of nuclear fuel cycle approaches, including direct disposal of spent fuel (the "once through" cycle), deep borehole disposal, and partial and full recycling. The Obama Administration's FY2017 funding request for this program was $249.9 million, a 22.6% increase from the enacted FY2016 level of $203.8 million.

Another DOE program related to reprocessing policy is the Mixed Oxide Fuel Fabrication Facility (MFFF) under construction at the Department's Savannah River Site in South Carolina. MFFF would produce fuel for commercial nuclear reactors using surplus nuclear weapons plutonium, as part of an agreement with Russia to reduce nuclear weapons material. Critics of the project contend that MFFF would subvert U.S. nonproliferation efforts by encouraging the use of plutonium fuel. Because of rising costs, the Obama Administration proposed to halt the MFFF project in FY2017 and pursue alternative plutonium disposition options.

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CRS Report RL34234, *Managing the Nuclear Fuel Cycle: Policy Implications of Expanding Global Access to Nuclear Power*, coordinated by (name redacted)

CRS Report R43125, *Mixed-Oxide Fuel Fabrication Plant and Plutonium Disposition: Management and Policy Issues*, by (name redacted) and (name redacted)

Advanced Nuclear Energy Technology

All currently operating commercial nuclear power plants in the United States are based on light water reactor (LWR) technology, in which ordinary water cools the reactor and acts as a neutron moderator to help sustain the nuclear chain reaction. DOE has long conducted research and development work on other, non-LWR nuclear technologies that could have advantages in safety, waste management, and cost. A growing number of private-sector firms are pursuing commercialization of advanced nuclear technologies as well.

Advanced nuclear energy technologies include high-temperature gas-cooled reactors, liquid metal-cooled reactors, and molten salt reactors (in which the nuclear fuel is dissolved in the coolant), among a wide range of other concepts. Research on advanced reactor coolants, materials, controls, and safety is carried out by DOE's Advanced Reactor Technologies program. The Obama Administration requested $73.5 million for the program in FY2017, a 27.7% reduction from the FY2016 level.

Private-sector nuclear technology companies contend that a major obstacle to commercializing advanced reactors is that NRC's licensing process is based on existing LWR technology. They have urged NRC to develop a licensing and regulatory framework that could apply to all nuclear concepts. They also have recommended a "staged review process" to provide conditional NRC approval for advanced reactor designs at key milestones toward the issuance of an operating license. NRC and DOE are currently implementing the Joint Advanced Non-Light Water Reactors Licensing Initiative to adapt existing general design criteria for LWRs for use by advanced reactor license applications.

Another proposal to promote advanced nuclear technology calls for DOE national laboratories to host reactor demonstration projects sponsored fully or partly by the private sector. Some public-private R&D on advanced nuclear technology is already being conducted at national labs under DOE's Gateway for Accelerated Innovation in Nuclear (GAIN) program. Legislation to promote private-sector reactor demonstrations at national labs and to require NRC to develop an advanced reactor licensing framework was considered in the 114th Congress.

For Further Information

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Biofuels

Biofuels—liquid transportation fuels produced from biomass feedstock—are often described as an alternative to conventional fuels. Some see promise in producing liquid fuels from a domestic feedstock that may reduce dependence on foreign sources of oil, contribute to improving rural economies, and lower greenhouse gas emissions. Others regard biofuels as potentially causing more harm to the environment (e.g., air and water quality concerns), encouraging landowners to

put more land into production, and being prohibitively expensive to produce. The debate about the feasibility of biofuels is complex, as policymakers consider a multitude of factors (e.g., feedstock costs, timeframe to reach substantial commercial-scale advanced biofuel production). The debate can be even more complicated when one considers that biofuels may be produced using numerous biomass feedstocks and conversion technologies. Thus, for each specific biofuel, a thorough assessment of the costs and benefits requires specific knowledge of the various factors involved.

Congress has expressed interest in biofuels for decades, with most of its attention on the production of "first-generation" biofuels (e.g., cornstarch ethanol). Farm bills have had a significant effect on biofuel research and development. Starting in 2002, the farm bills have contained an energy title with several programs focused on assisting biofuel production (see "Agriculture" section for additional farm bill related research). While commercial-scale production of "first-generation" biofuels is well established, commercial-scale production for some advanced biofuels (e.g., cellulosic ethanol) is in its infancy.

In 2007, Congress expanded one policy that has supported an increase in advanced biofuel production—the Renewable Fuel Standard (RFS). The RFS requires U.S. transportation fuel to contain a minimum volume of biofuel, a significant percentage of which is gradually to come from advanced biofuels. However, the RFS has been under scrutiny for various reasons, including the reduction by the Environmental Protection Agency (EPA) in the total renewable fuel volume below what was required by statute and concerns about RFS compliance. This has created significant uncertainty for certain stakeholders, with the result that some of the advanced biofuel targets are not being met. An overarching issue is that the policy may require more biofuel to be produced than can be used given the existing motor fuel distribution infrastructure and the limited fleet of passenger vehicles that are built to run on higher percentage blends of biofuels. A continuing issue is whether a domestic biofuel industry is necessary for national defense, and what, if any, role the military might take regarding biofuel production and purchase. Congress could also consider whether to modify various biofuel promotional efforts, or to maintain the status quo.

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CRS Report R43325, *The Renewable Fuel Standard (RFS): In Brief*, by (name redacted)

Off-Shore Energy Development Technologies

Technological innovations are key drivers of U.S. ocean energy development. They may facilitate exploration of previously inaccessible resources, provide cost efficiencies in a low-oil-price environment, address offshore safety and environmental concerns, and address obstacles in the emerging offshore renewable energy industry. Private industry, universities, and government are all involved in ocean energy R&D. At the federal level, the Department of Energy (DOE) and the Department of the Interior (DOI) both support ocean energy research.

The 115th Congress may consider issues related to deepwater oil and gas drilling technologies. Interest in expanding deepwater operations has prompted advances such as ultra-deepwater-capable drilling vessels and equipment. The oil and gas industry and federal regulators have also focused on safety improvements to reduce the likelihood of catastrophic oil spills. In April 2016, DOI released final safety regulations that tighten requirements for offshore blowout preventer

systems and other well control equipment. Issues include the cost to industry of meeting the rule's technological requirements and the time required to do so.

Congress may also consider technology issues related to offshore drilling in the Arctic, where icy conditions and infrastructure gaps pose challenges for the economic viability and safety of mineral exploration. A focus of industry R&D is on technology to extend the Arctic drilling season beyond the brief periods where sea ice is absent—for example, by developing ice-capable mobile offshore drilling units (MODUs). DOI finalized safety regulations for Arctic exploratory drilling in July 2016. Some have argued that they are too costly for industry and give inadequate weight to available technologies (such as those for well capping) that could reduce safety costs. Others question whether any rules or technologies can adequately ensure drilling safety in the Arctic given the environmental risks.

Among renewable ocean energy technologies, only wind energy is poised for commercial application in U.S. waters. In December 2016, the first U.S. offshore wind farm, off of Rhode Island, began regular operations. Developers are exploring technologies to increase offshore turbine efficiency and reduce costs, including floating turbines for deep waters. Other research explores improvements to electrical infrastructure, such as integrating transmission networks for multiple projects. An issue for Congress is whether and how to support or incentivize R&D for wind and other ocean renewables.

For Further Information

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CRS Report R44504, *The Bureau of Ocean Energy Management's Five-Year Program for Offshore Oil and Gas Leasing: History and Final Program for 2017-2022*, by (name redacted), (name redacted), and (name redacted)

CRS Report R42942, *Deepwater Horizon Oil Spill: Recent Activities and Ongoing Developments*, by (name redacted)

CRS Report R41153, *Changes in the Arctic: Background and Issues for Congress*, coordinated by (name redacted)

CRS Report R40175, *Wind Energy: Offshore Permitting*, by (name redacted)

ITER

ITER (formerly known as the International Thermonuclear Experimental Reactor) is an international fusion energy research facility currently under construction in Cadarache, France. When completed, ITER is to be the world's largest fusion reactor and the first capable of producing more energy than it consumes. Although the energy output from ITER will not be harnessed to produce electricity, fusion researchers see ITER as the next step toward implementation of fusion energy as a power source.

ITER is an international collaboration. Along with the United States, the partners are the European Union, China, India, Japan, Russia, and South Korea. The United States withdrew from the initial design phase of ITER in 1998 at congressional direction, largely because of concerns about cost and scope. The project was restructured, and the United States rejoined in 2003. The formal international agreement to build the facility was approved in 2006.

The European Union, as host, is responsible for 45% of the construction cost, while the United States and the other participating countries are responsible for 9% each. Most of the U.S. share

(which was $145 million in FY2016) is being contributed in kind, in the form of components and equipment sourced mostly from U.S. companies, universities, and national laboratories.

In recent years, management issues, schedule delays, and cost growth have again made ITER controversial, with repeated proposals in Congress to terminate U.S. participation. A central concern is that U.S. funding for ITER may be crowding out funding for the domestic fusion research program. In 2016, the Department of Energy (DOE) submitted a congressionally mandated report that recommended continued U.S. participation through FY2018 and reevaluating U.S. participation prior to submittal of the FY2019 budget.

First operation of ITER is now planned for 2027. Once operational, the lifespan of the facility is expected to be approximately 20 years. During the operation phase, and during subsequent deactivation and decommissioning, the agreed U.S. cost share is 13%.

For More Information

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Environment and Natural Resources

Science and technology play an increasingly large role in environmental issues. Science- and technology-related environmental issues that may come before the 115th Congress include climate change science, carbon sequestration, water science, and desalination.

Climate Change Science and Technology

Climate change, including the policy questions of whether and how the federal government might address it, is likely to appear on the agenda of the 115th Congress. Science and technology considerations will underpin virtually all congressional deliberations on the topic. Despite portrayals in popular media about controversies in climate change science, almost all climate scientists agree on certain important points: the Earth's climate has been changing; human-related emissions of greenhouse gases (GHG) are accumulating in the atmosphere (as rising concentrations); and that rising concentrations will lead to additional global warming and other climate changes. A large majority of scientists also agree that most of the observed global climate change since the 1970s has been human-related, and that continued GHG emissions would lead to important adverse impacts—even catastrophic for some populations; some, however, consider that even under current GHG emission trajectories, the potential impacts would be modest and manageable. The focus of climate change science may shift increasingly toward greater precision in climate projections, impacts on society, and probabilistic characterization of uncertainties, especially to assist local and regional impact assessment and risk management decision making. In light of the growing consensus on the science of human-induced climate change, Congress may shift attention more toward assessment of options to manage risks. This may include the magnitude and emphasis of federal support for climate-related technology for GHG emission abatement, geoengineering, and adaptation or resilience to impacts.

U.S. Global Change Research Program (USGCRP) is an interagency mechanism, required by the Global Change Research Act of 1990 (P.L. 101-606) that coordinates and integrates global change research across 10 government agencies. For FY2017, USGCRP has expressed three thematic priorities: climate, water cycle extremes in the context of climate change, and methane cycling in the context of the carbon cycle.

Most climate change-related funding is aimed at advancing "clean energy." This is because most human-related GHG emissions come from production, distribution, and combustion of fossil

fuels, particularly for electricity generation and transportation. Many analysts see a decades-long path to decarbonization of the world's energy economy as a primary option to halting the human influence on climate, while potentially providing security and health benefits; some see potential carbon capture and sequestration (CCS) technologies as key to preventing carbon dioxide emissions while preserving a large place for coal and other fossil fuels in the energy economy.

Members may deliberate on the appropriate degree and means of federal support for advancing and deploying new technologies. Because some innovative technologies are still in the research phase, and because of market inefficiencies and barriers to economical uptake of some technologies, Congress has provided billions of dollars of existing federal support, including numerous tax incentives, for energy technologies, unevenly distributed across types of technologies. The programs range from basic research, through technology development and demonstration of selected technologies, to incentives to promote their commercial deployment. Some focus on "supply-push" of technologies, while others emphasize "demand-pull." Existing programs support technologies that variously lead to greater GHG emissions (e.g., fossil fuel extraction and utilization technologies) or would lower GHG emissions (e.g., more efficient and renewable energy technologies). Cleaner energy technologies can produce public health benefits additional to climate benefits, while shifts in the energy economy can also pose transitional challenges to employment and communities. The magnitude of federal expenditures for climate change, their effectiveness, and priorities may be topics for Congress, particularly in light of budget objectives.

The 115th Congress may consider legislation that affects existing programs or establishes new ones. One priority voiced by many in Congress is tax reform; changes in tax incentives could influence the types and rates of technology advance. In addition, legislation has been proposed in past Congresses to levy GHG emission fees or "carbon taxes" to broaden the tax base, to reduce other distortionary taxes, and to promote cleaner technologies. More specifically, pricing of GHG emissions would promote demand for more efficient and lower-emitting technologies, potentially driving innovation and market-based technology change. Emission fees could also be used in part to finance basic research in which the private sector tends to underinvest because of its risks and the difficulty of capturing all the benefits of successful R&D.

Technologies to support resilience to future climate change have also been proposed in past Congresses. Because the climate will continue to change, due to both natural and human-related causes, Congress may address the federal role in facilitating effective private decision making to anticipate and be resilient to changes. It may also consider efforts already begun to incorporate climate change projections into agency management of federal resources, infrastructure and operations, and requirements and incentives in federal programs that may encourage or impede adaptation. Effective decisions would all depend on the adequacy and appropriate use of scientific information and available technologies.

For Further Information

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CRS Report R42532, *Carbon Capture and Sequestration (CCS): A Primer*, by (name redacted)

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CRS Report R43915, *Climate Change Adaptation by Federal Agencies: An Analysis of Plans and Issues for Congress*, coordinated by (name redacted)

CRS Report R43199, *Energy-Water Nexus: The Energy Sector's Water Use*, by (name redacted)

CRS Report R41153, *Changes in the Arctic: Background and Issues for Congress*, coordinated by (name redacted)

Carbon Capture and Sequestration

Carbon capture and sequestration (or storage)—known as CCS—is a physical process that involves capturing manmade carbon dioxide (CO_2) at its source and storing it indefinitely before its release to the atmosphere. CCS could reduce the amount of CO_2 emitted to the atmosphere while allowing the continued use of fossil fuels at power plants and other large industrial facilities. An integrated CCS system would include three main steps: (1) capturing CO_2 at its source and separating it from other gases; (2) purifying, compressing, and transporting the captured CO_2 to the sequestration site; and (3) injecting the CO_2 into subsurface geological reservoirs. Following its injection into a subsurface reservoir, the CO_2 would need to be monitored for leakage and to verify that it remains in the target geological reservoir. Once injection operations cease, a responsible party would need to take title to the injected CO_2 and ensure that it stays underground in perpetuity.

The U.S. Department of Energy (DOE) has pursued research and development of aspects of the three main steps leading to an integrated CCS system since 1997. Congress has appropriated more than $7 billion in total since FY2008 for CCS research, development, and demonstration (RD&D) at DOE's Office of Fossil Energy. Nearly half of total funding, $3.4 billion, came from the American Recovery and Reinvestment Act (P.L. 111-5). Authority to expend Recovery Act funding expired at the end of FY2015.

To date, no commercial ventures in the United States capture, transport, and inject large quantities of CO_2 (e.g., 1 million tons per year or more) solely for the purposes of carbon sequestration. However, the CCS RD&D program has embarked on commercial-scale demonstration projects for CO_2 capture, injection, and storage. The success of these demonstration projects will likely bear heavily on the future outlook for widespread deployment of CCS technologies as a strategy for preventing large quantities of CO_2 from reaching the atmosphere while power plants continue to burn fossil fuels, mainly coal. Congress may review the results from these demonstration projects as they progress in order to gauge whether DOE is on track to meet its goal of allowing for an advanced CCS technology portfolio to be ready by 2020 for large-scale demonstration and deployment in the United States.

The U.S. Environmental Protection Agency's (EPA's) final rule for reducing CO_2 emissions from new fossil fuel power plants, part of the Obama Administration's Clean Power Plan (CPP), found newly constructed power plants incorporating partial CCS to be the Best System of Emission Reduction (BSER). EPA determined that the BSER is technically feasible and available at reasonable cost. EPA based its claim, in part, on an example of demonstrated, full-scale operations in the electricity-generating industry, as well as on other smaller projects that are reasonably predictive of results at full scale. In a separate rule, also part of the CPP, EPA found that CCS was not the BSER for existing power plants.

For Further Information

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CRS Report R41325, *Carbon Capture: A Technology Assessment*, by (name redacted)

Water Technologies, Science, and Infrastructure Research

Reliable water quantity and quality is essential for the U.S. population, ecosystems, and economy, including agriculture and energy production. Because of the diverse uses of water, federal research activities span numerous departments, agencies, and laboratories; the federal government also supports water research through grants to universities and other researchers. Recent droughts, flood disasters, and drinking water contaminations (e.g., algal toxins in Lake Erie and lead in drinking water in Flint, MI) have increased attention to water science and technology. The 115th Congress may consider multiple water research topics including:

- Water monitoring infrastructure and programs, including water quality monitoring activities, stream gages, and remote sensing investments (see "Earth-Observing Satellites");
- Water efficiency technologies and practices, such as improved irrigation technologies (see "Agricultural Research"), and science to support their adoption;
- Water augmentation technologies and science to support their adoption, including urban and agricultural groundwater recharge and stormwater capture techniques, water reuse technologies, and desalination (see "Desalination");
- Research on altering the operation of existing reservoirs and augmenting hydropower generation;
- Technologies and materials for monitoring and rehabilitating aging infrastructure;
- Access to water data (e.g., the Open Water Data Initiative); and
- Coordination and direction of the federal water science and research portfolio.

Various entities have produced reports discussing aspects of the water research portfolio. For example, a 2014 Government Accountability Office (GAO) report, *Freshwater: Supply Concerns Continue and Uncertainties Complicate Planning*, found that state water management activities could benefit from improved federal water data; and a 2016 GAO report, *Municipal Freshwater Scarcity: Using Technology to Improve Distribution System Efficiency and Tap Nontraditional Water Sources*, assessed utility-scale water technologies including leak detection, metering, wastewater reuse, stormwater capture, and desalination. The National Academy of Sciences published reports on greywater and stormwater in 2016, wastewater produced from oil and gas development in 2016, Gulf of Mexico restoration monitoring in 2015, and wastewater reuse in 2012.

For Further Information

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CRS Report R43199, *Energy-Water Nexus: The Energy Sector's Water Use*, by (name redacted)

Desalination

Water shortages have heightened interest in desalination for augmenting water supplies. Desalination can create a new high-quality, local freshwater supply that is independent of weather conditions. At issue for Congress is what should be the federal role in supporting desalination adoption and desalination technology research. The federal government is currently involved in various desalination research activities that span multiple departments, including for military applications. Additionally, some states, universities, and private entities also undertake and support desalination research.

Desalination consists of the treatment of a feed water of seawater or less saline water known as brackish water. The treatment results in not only freshwater but also saline wastewater known as concentrate or brine. The most common desalination technology in the United States is reverse osmosis, which uses permeable membranes to separate freshwater from saline waters.

The U.S. prospects for desalinated water as a municipal water supply vary for brackish water and seawater. Some interior and coastal communities already are desalinating brackish sources to augment municipal water supplies; the United States is currently a global leader in brackish desalination adoption. Some coastal communities are looking to desalinate seawater or estuarine water; seawater desalination is more costly and requires more energy than brackish water desalination.

Although desalination costs have dropped in recent decades, significant further decline may not happen with existing technologies. For reverse osmosis, electricity expenses represent one-third to one-half of the operating cost. Researchers are pursuing emerging desalination technologies (e.g., forward osmosis and capacitive deionization) in an effort to improve desalination's energy efficiency (e.g., use of waste heat as an energy source), reduce its environmental impacts (e.g., less brine requiring disposal), and improve its cost competitiveness as an intermittent or base load water supply.

In the Water Infrastructure Improvements for the Nation Act (P.L. 114-322), the 114th Congress extended and expanded the authorization for the Department of the Interior to support desalination RD&D. In its FY2017 budget request, the Department of Energy proposed a new low-energy desalination manufacturing research initiative. Desalination issues before the 115th Congress may include how to prioritize federal desalination research, the appropriations level for federally supported desalination research and projects, and the evolving federal-state-local regulatory context for desalination projects.

For Further Information

(name redacted), Specialist in Natural Resources Policy ([redacted]@crs.loc.gov, 7.)

CRS Report R40477, *Desalination and Membrane Technologies: Federal Research and Adoption Issues*, by (name redacted)

Homeland Security

The federal government spends billions of dollars supporting research and development to protect the homeland. Some of the issues that the 115th Congress may consider include how the

Department of Homeland Security performs research and development and federal efforts to develop and procure new medical countermeasures against chemical, biological, radiological, and nuclear agents.

R&D in the Department of Homeland Security

The Department of Homeland Security (DHS) has identified five core missions: to prevent terrorism and enhance security, to secure and manage the borders, to enforce and administer immigration laws, to safeguard and secure cyberspace, and to ensure resilience to disasters. New technology resulting from research and development can contribute to all these goals. The Directorate of Science and Technology has primary responsibility for establishing, administering, and coordinating DHS R&D activities. The Domestic Nuclear Detection Office (DNDO) is responsible for R&D relating to nuclear and radiological threats. Several other DHS components, including the Coast Guard, also fund R&D and R&D-related activities related to their missions.

Coordination of DHS R&D is a long-standing congressional concern. In 2012, GAO concluded that because so many components of the department are involved, it is difficult for DHS to oversee R&D department-wide. In January 2014, the joint explanatory statement for the Consolidated Appropriations Act, 2014 (P.L. 113-76) directed DHS to implement and report on new policies for R&D prioritization. It also directed DHS to review and implement policies and guidance for defining and overseeing R&D department-wide. In July 2014, GAO reported that DHS had updated its guidance to include a definition of R&D and was conducting R&D portfolio reviews across the department, but that it had not yet developed policy guidance for DHS-wide R&D oversight, coordination, and tracking. In December 2015, the explanatory statement for the Consolidated Appropriations Act, 2016 (P.L. 114-113) stated that DHS "lacks a mechanism for capturing and understanding research and development (R&D) activities conducted across DHS, as well as coordinating R&D to reflect departmental priorities." The Common Appropriations Structure that DHS introduced in February 2016 in its FY2017 budget request includes an account titled Research and Development for each DHS component. It remains to be seen whether this change will help to address congressional concerns about DHS-wide R&D coordination.

DHS has reorganized its R&D-related activities several times. DNDO and the Office of Health Affairs (OHA) were both created largely by reorganizing elements of the S&T Directorate. In the explanatory statement for the Consolidated and Further Continuing Appropriations Act, 2013 (P.L. 113-6), Congress directed DHS to evaluate the option of merging DNDO and OHA and realigning some of their functions, possibly including R&D, into other components. In 2015, DHS proposed the creation of a new Office of Chemical, Biological, Radiological, Nuclear, and Explosives Defense, made up of DNDO and OHA together with smaller elements of other programs. In 2016, it included this proposal in the FY2017 budget request. The 115th Congress may consider legislation to authorize the establishment and activities of this new office.

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Chemical, Biological, Radiological, and Nuclear Medical Countermeasures

The anthrax attacks of 2001 highlighted the nation's vulnerability to biological terrorism. The federal government responded to these attacks by increasing efforts to protect civilians against chemical, biological, radiological, and nuclear (CBRN) terrorism. Effective medical

countermeasures, such as drugs or vaccines, could reduce the impact of a CBRN attack. Policymakers identified a lack of such countermeasures as a challenge to responding to the CBRN threat. To address this gap, the federal government created several programs to encourage private sector development of new CBRN medical countermeasures. Despite these efforts, the federal government still lacks medical countermeasures for many CBRN threats, including Ebola.

The Biomedical Advanced Research and Development Authority (BARDA) and Project BioShield are two key pieces of the federal efforts supporting the development and procurement of new CBRN medical countermeasures. BARDA directly funds the advanced development of countermeasures through contracts with private sector developers. Project BioShield provides a procurement mechanism to remove market uncertainty for countermeasure developers. It allows the federal government to agree to buy a countermeasure up to 10 years before the product is likely to finish development. Recent Congresses have modified these and related programs to improve their performance, efficiency, and transparency to oversight. However, some key issues remain unresolved, including those related to appropriations, interagency coordination, and countermeasure prioritization. In addition to questions regarding the amount of funding, Congress may decide whether to return to funding Project BioShield through a multiyear advance appropriation. Policymakers may consider whether the new planning and transparency requirements have sufficiently enhanced coordination of the multiagency countermeasure development enterprise. Additionally, Congress may consider whether the countermeasure prioritization process appropriately balances the need to address traditional threats such as anthrax and smallpox with the threat posed by emerging infectious diseases such as Ebola.

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Information Technology

The rapid pace of advancements in information technology presents several issues for congressional policymakers, including those related to cybersecurity, broadband deployment, access to broadband networks and net neutrality, the Internet of Things, cryptography and law-enforcement challenges, and federal networking R&D.

Cybersecurity

The 113th and 114th Congresses saw significant legislative activity relating to cybersecurity, including the enactment of several laws with provisions on the security of federal information systems and the sharing of cybersecurity information across critical infrastructure sectors, among other issues. Those laws, along with more than 50 other statutes, presidential directives, and related authorities, provide a complex federal policy framework for U.S. cybersecurity.

The 115th Congress may face a number of significant issues related to cybersecurity, in addition to oversight of implementation of enacted laws. Among those issues are

- cybersecurity for critical infrastructure, given that most of it is owned by the private sector;
- prevention of and response to cybercrime, especially given its substantially international character;
- the relationship between cyberspace and national security; and
- ways that federal funding should be invested to protect information systems.

In addition to such short- and medium-term issues, Congress may consider responses to a number of long-term challenges, including the following:

- the degree to which information systems can be designed with security built in, in the face of economic obstacles and the other challenges;
- ways to correct an economic incentive structure for cybersecurity that has often been called distorted or even perverse, with cybercrime widely regarded as cheap, profitable, and comparatively safe for the criminals, while cybersecurity is often considered expensive and imperfect, with uncertain economic returns;
- finding consensus on a consistent and effective model for approaching cybersecurity, given stakeholders from different sectors and different work subcultures with varying needs, goals, and perspectives; and
- a rapidly evolving cyberspace environment that both complicates the threat environment and may pose opportunities for shaping the direction of that evolution toward greater security.

For Further Information

(name redacted), Senior Specialist in Science and Technology ([redacted]@crs.loc.gov, 7.)

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Broadband Deployment

Broadband—whether delivered wirelessly or via fiber, cable modem, or copper wire—is increasingly the technology underlying telecommunications services such as voice, video, and data. Since the initial deployment of broadband in the late 1990s, Congress has viewed broadband infrastructure deployment as a means to improve regional economic development, and in the long term, to create jobs. According to the Federal Communications Commission's (FCC's) National Broadband Plan, the lack of adequate broadband availability is most pressing in rural America, where the cost of serving large geographical areas, coupled with low population densities, often reduce economic incentives for telecommunications providers to invest in and maintain broadband infrastructure and service. The National Broadband Plan also identified broadband adoption as a problem, wherein one in three Americans have broadband available, but choose not to subscribe. Populations continuing to lag behind in broadband adoption include people with low incomes, seniors, minorities, the less-educated, non-family households, and the non-employed.

The 115th Congress may address a range of broadband-related issues. These may include the continued transition of the telephone-era Universal Service Fund from a voice to a broadband-based focus, infrastructure legislation that may include incentives for broadband buildout, reauthorization of the broadband loan program in the farm bill, the development of new wireless spectrum policies, and to what extent, if any, regulation is necessary to ensure an open Internet. Additionally, the 115th Congress may choose to examine the existing regulatory structure and consider possible revision of the 1996 Telecommunications Act and its underlying statute, the Communications Act of 1934. Both the convergence of telecommunications providers and markets and the transition to an Internet Protocol (IP) based network have, according to a growing number of policymakers, made it necessary to consider revising the current regulatory framework. How a possible revision might create additional incentives for investment in,

deployment of, and subscribership to U.S. broadband infrastructure may be among many issues under consideration.

To the extent that Congress may consider various options for further enhancing broadband deployment, a key issue is how to develop and implement federal policies intended to increase the nation's broadband availability and adoption, while at the same time minimizing any deleterious effects that government intervention in the marketplace may have on competition and private sector investment.

For Further Information

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CRS Report RL33816, *Broadband Loan and Grant Programs in the USDA's Rural Utilities Service*, by (name redacted)

Access to Broadband Networks and the Net Neutrality Debate

As policymakers continue to debate telecommunications reform, a major point of contention is whether action is needed to ensure unfettered access to the Internet. The move to place restrictions on the owners of the networks that compose and provide access to the Internet, to ensure equal access and non-discriminatory treatment, is referred to as "net neutrality." While there is no single accepted definition of "net neutrality," most agree that any such definition should include the general principles that owners of the networks that compose and provide access to the Internet (i.e., broadband access providers) should not control how consumers lawfully use that network, and should not be able to discriminate against content provider access to that network. A focal point in the debate centers on whether it is necessary for policymakers to take steps to ensure "unfettered" access to the Internet for content, services, and applications providers, as well as consumers, and if so, what these steps should be. Some policymakers contend that more specific regulatory guidelines are necessary to protect the marketplace from potential abuses which could threaten the net neutrality concept. Others contend that existing laws and policies are sufficient to deal with potential anti-competitive behavior and that additional regulations would have negative effects on the expansion and future development of the Internet.

What, if any, action should be taken to ensure "net neutrality" is part of the overall discussion regarding broadband regulation. As the marketplace for broadband continues to evolve, some contend that no new regulations are needed, and if enacted will slow deployment of and access to the Internet, as well as limit innovation. Others, however, contend that the consolidation of broadband providers, coupled with their diversification into content, has the potential to lead to discriminatory behaviors which conflict with net neutrality principles. The two potential behaviors most often cited are the network providers' ability to control access to and the pricing of broadband facilities, and the incentive to favor network-owned or affiliated content, thereby placing unaffiliated content providers at a competitive disadvantage.

A consensus on the net neutrality issue remains elusive. Some Members of Congress support the FCC's adoption of the 2015 Open Internet Order establishing regulations for broadband Internet access. Others, while acknowledging that some regulation may be needed, argue that the FCC has overstepped its authority and advocate that the FCC look to Congress for guidance to amend the current law to update FCC authority before action is taken. Still others argue that regulation of the

Internet is not only unnecessary, but harmful. Broadband regulation and the FCC's authority to implement such regulations is an issue of growing importance in the wide ranging policy debate over broadband access.

For Further Information

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The Internet of Things

The Internet of Things (IoT) may be a focal point of far-reaching debates during the 115th Congress. The term refers to networks of objects with two features—a unique identifier and Internet connectivity. Such "smart" objects can form systems that communicate among themselves, usually in concert with computers, allowing automated and remote control of many independent processes and potentially transforming them into integrated systems. Such objects may include vehicles, appliances, medical devices, electric grids, transportation infrastructure, manufacturing equipment, building systems, and so forth. The IoT may potentially impact homes and communities, factories and cities, and nearly every sector of the economy, both domestically and globally, among them agriculture (precision farming), health (medical devices), and transportation (self-driving automobiles and unmanned aerial vehicles).

An increasing number of these systems require access to radio frequency spectrum in order to connect to the Internet or other networks. The development of fifth-generation (5G) wireless technologies is likely to develop in tandem with the IoT.

Although the full extent and nature of impacts of the IoT remain uncertain, some economic analyses predict that it will contribute trillions of dollars to economic growth over the next decade. The IoT, for example, may be able to facilitate more integrated and functional infrastructure, especially in "smart cities," through improvements in transportation, utilities, and other municipal services. Sectors that may be particularly affected are agriculture, energy, government, health care, manufacturing, and transportation.

The federal government may play an important role in enabling the development and deployment of the IoT, including R&D, standards, regulation, and support for testbeds and demonstration projects. No single federal agency has overall responsibility for the IoT. Various agencies have relevant regulatory, sector-specific, and other mission-related responsibilities, such as the Departments of Commerce, Health, Energy, Transportation, and Defense, the National Science Foundation, the Federal Communications Commission, and the Federal Trade Commission.

The range of issues that might be the subject of congressional activity includes the following:

- security of objects and the systems and networks to which they are connected;
- privacy of the information gathered and transmitted by objects;
- standards for the IoT, especially with respect to connectivity;
- transition to a new Internet Protocol (IPv6) that can handle the anticipated exponential increase in the number of IP addresses required by the IoT;
- methods for updating the software used by IoT objects in response to security and other needs;

- energy management for IoT objects, especially those not connected to the electric grid; and
- the role of the federal government in development and deployment, standards, regulation, and communications, including the impact of federal rules regarding "net neutrality."

The Internet of Things represents more than devices connected through networks, and more than Internet or radio frequency spectrum policy. Its growth will likely require significant changes in—and coordination among—many government departments and agencies.

For Further Information

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CRS Report R44227, *The Internet of Things: Frequently Asked Questions*, by (name redacted)

Cryptography and Law Enforcement "Going Dark"

Changing technology presents opportunities and challenges for U.S. law enforcement. Some technological advances have arguably opened a treasure trove of information for investigators and analysts. Others have presented unique hurdles. While some feel that law enforcement now has more information available to them than ever before, others contend that law enforcement is "going dark" as their investigative capabilities are outpaced by the speed of technological change. These hurdles for law enforcement include strong, end-to-end (or what law enforcement has sometimes called "warrant-proof") encryption; provider limits on data retention; bounds on companies' technological capabilities to provide specific data points to law enforcement; tools facilitating anonymity online; and a landscape of mixed wireless, cellular, and other networks through which individuals and information are constantly passing. As such, law enforcement cannot access certain information they otherwise may be authorized to obtain.

The tension between law enforcement capabilities and technological change has received congressional attention for several decades. For instance, in the 1990s the "crypto wars" pitted the government against technology companies, and this tension was highlighted by proposals to build in vulnerabilities, or back doors, to certain encrypted communications devices as well as to restrict the export of strong encryption code. In addition, Congress passed the Communications Assistance for Law Enforcement Act (CALEA; P.L. 103-414) in 1994 to help law enforcement maintain their ability to execute authorized electronic surveillance as telecommunications providers turned to digital and wireless technology.

The "going dark" debate originally focused on data in motion, or law enforcement's ability to intercept real-time communications. However, more recent technology changes have impacted law enforcement's capacity to access not only communications but stored content, or data at rest. The Obama Administration urged the technology community to develop a means to assist law enforcement in accessing encrypted data and took steps to bolster law enforcement's technology capabilities. In addition, policymakers have been evaluating whether legislation may be an appropriate response to the problems posed by encryption.

For Further Information

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CRS Report R44642, *Encryption: Frequently Asked Questions*, by (name redacted)

The Networking and Information Technology Research and Development Program

Congress passed the High-Performance Computing and Communications Program (HPCC) Act of 1991 (P.L. 102-194) to enhance the effectiveness of federally funded information technology (IT) R&D programs and to encourage coordination among agencies conducting such research.

Proponents of federal support of IT R&D assert that it has produced positive outcomes for the country and played a crucial role in supporting long-term research into fundamental aspects of computing. Such fundamentals may provide broad practical benefits, but generally take years to realize. Additionally, the unanticipated results of research are often as important as the anticipated results. Another aspect of government-funded IT research is that it often leads to open standards, something that many perceive as beneficial, encouraging deployment and further investment. Industry, on the other hand, is more inclined to invest in proprietary products and will diverge from a common standard when there is a potential competitive or financial advantage to do so. Supporters believe that the outcomes achieved through the various funding programs create a synergistic environment in which both fundamental and application-driven research are conducted, benefitting government, industry, academia, and the public. Critics, however, assert that the government, through its funding mechanisms, may be picking "winners and losers" in technological development, a role more properly residing with the market. For example, the size of the Networking and Information Technology Research and Development (NITRD) Program may encourage industry to follow the government's lead on research directions rather than selecting those directions itself.

The NITRD Program is funded through appropriations to its individual agencies, so support for it will likely be part of the federal budget debate in Congress.

For Further Information

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Physical and Material Sciences

Some of the policy issues in the physical and material sciences that the 115th Congress may address include funding and oversight of the National Science Foundation and the multiagency initiative supporting research and development in the emerging field of nanotechnology.

National Science Foundation

The National Science Foundation (NSF) supports basic research and education in the non-medical sciences and engineering and is a primary source of federal support for U.S. university research. It is also responsible for significant shares of the federal science, technology, engineering, and mathematics (STEM) education program portfolio and federal STEM student aid and support. Enacted funding for NSF in FY2016 was $7.463 billion.

The NSF's funding levels and congressional direction of funding have been long-standing issues of congressional concern. At various points in NSF's history, some policymakers have pursued a policy of authorizing large increases in the NSF budget over a defined period of time (e.g., a

100% increase over seven years, sometimes referred to as a "doubling path policy"). Actual appropriations have rarely reached authorized levels, and growth in NSF's budget has slowed in recent years. Advocates of large funding increases assert that steep and fast increases in NSF funding are necessary to ensure U.S. competitiveness. Other analysts argue that steady, reliable funding increases over longer periods of time would be less disruptive to the U.S. scientific and technological enterprise. Alternatively, some policymakers seek no additional increases in NSF funding in light of the federal deficit and spending caps. Additionally, some policymakers prefer to direct federal funding to research with a more applied or mission-oriented focus than that which is typically funded at NSF.

Policy issues of particular interest that the 115th Congress may continue to address include the selection, funding, and management of large-scale construction projects, scientific instruments, and facilities, including the use of management fees and the construction of new large research vessels; the foundation's grant-making process, including its peer review process; and the effectiveness and costs of NSF's use of non-federal personnel—through the Intergovernmental Personnel Act (IPA) program—often called "rotators." Further, analysts and legislators have periodically debated questions about prioritizing NSF funding for the physical sciences and engineering over funding for the social, behavioral, and economic sciences, as well as expanding support for multidisciplinary funding. Other lasting federal policy issues for the NSF focus on the balance between scientific independence and accountability to taxpayers; the geographic distribution of grants; NSF's role in broadening participation in STEM fields; support for various STEM education programs; and the production of data about the U.S. scientific and technological enterprise.

For Further Information

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CRS Report R44679, *The National Science Foundation: FY2017 Appropriations Status and Funding History*, by (name redacted) and (name redacted)

Nanotechnology and the National Nanotechnology Initiative

Nanoscale science, engineering, and technology—commonly referred to collectively as nanotechnology—is believed by many to offer extraordinary economic and societal benefits. Nanotechnology R&D is directed toward the understanding and control of matter at dimensions of roughly 1 to 100 nanometers (a nanometer is one-billionth of a meter). At this size, the properties of matter can differ in fundamental and potentially useful ways from the properties of individual atoms and molecules and of bulk matter.

Many current applications of nanotechnology are evolutionary in nature, offering incremental improvements in existing products and generally modest economic and societal benefits. For example, nanotechnology is being used in automobile bumpers, cargo beds, and step-assists to reduce weight, increase resistance to dents and scratches, and eliminate rust; in clothes to increase stain- and wrinkle-resistance; and in sporting goods to improve performance. Other nanotechnology innovations play a central role in current applications with substantial economic value. For example, nanotechnology is a fundamental enabling technology in nearly all semiconductors and is key to improvements in chip speed, size, weight, and energy use. Similarly, nanotechnology has substantially increased the storage density of non-volatile flash memory and computer hard drives. In the longer term, some believe that nanotechnology may deliver revolutionary advances with profound economic and societal implications, such as detection and treatment of cancer and other diseases; clean, inexpensive, renewable power through energy

transformation, storage, and transmission technologies; affordable, scalable, and portable water filtration systems; self-healing materials; and high-density memory devices.

The development of this emerging field has been fostered by significant and sustained public investments in nanotechnology R&D. In 2001, President Clinton launched the multi-agency National Nanotechnology Initiative (NNI) to accelerate and focus nanotechnology R&D to achieve scientific breakthroughs and to enable the development of new materials, tools, and products. More than 60 nations subsequently established programs similar to the NNI.

Through FY2016, Congress has appropriated approximately $21.8 billion for nanotechnology R&D; the President requested $1.4 billion in FY2017 funding. In 2003, Congress enacted the 21st Century Nanotechnology Research and Development Act (P.L. 108-153), providing a legislative foundation for some of the activities of the NNI, establishing programs, assigning agency responsibilities, and setting authorization levels through FY2008. Legislation has been introduced in successive Congresses to amend and reauthorize the act though none has been enacted into law. Congress has directed its attention primarily to three topics that may affect the realization of nanotechnology's hoped-for potential: R&D funding; U.S. competitiveness; and environmental, health, and safety (EHS) concerns.

For Further Information

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CRS Report RL34614, *Nanotechnology and Environmental, Health, and Safety: Issues for Consideration*, by (name redacted)

Space

Congress has historically had a strong interest in space policy issues. Space topics that may come before the 115th Congress include the funding and oversight of the National Aeronautics and Space Administration (NASA) and issues related to the commercialization of space and to Earth-observing satellites.

NASA

Spaceflight has attracted strong congressional interest since the establishment of NASA in 1958. Issues include the goals and strategy of NASA's human spaceflight program, the impact of constrained budgets on NASA's other missions, and the future of NASA's Earth Science program. The 115th Congress will also likely address NASA reauthorization legislation, which was considered in both chambers in the 113th and 114th Congresses but not enacted.

With the end of the space shuttle program in July 2011, the United States lost the capability to launch astronauts into space. Since that time, NASA has relied on Russian spacecraft for crew transport to the International Space Station (ISS). For ISS cargo transport, NASA-contracted U.S. commercial flights have been delivering payloads of supplies and equipment since October 2012.

As directed by the NASA Authorization Act of 2010 (P.L. 111-267), NASA is pursuing a two-track strategy for human spaceflight. First, for transport to low Earth orbit, including the ISS, NASA is supporting commercial development of a crew transport capability like the commercial

cargo capability achieved in 2012. Commercial crew transportation services are scheduled to become operational in 2018. The Government Accountability Office has reported that this date may slip to 2019.

Second, for human exploration beyond Earth orbit, NASA is developing a new crew capsule called Orion and a new heavy-lift rocket called the Space Launch System (SLS). The first crewed test flight of Orion and the SLS is scheduled for 2023. Details of the subsequent exploration missions of Orion and the SLS remain to be determined.

Rapid developments in the commercial space sector may change the relationship between NASA and industry. For example, in early 2017, SpaceX announced plans for a commercial flight in 2018 that would carry two passengers around the Moon and back. Some observers see this sort of development as potentially competing with NASA's human spaceflight plans. More broadly, the emergence of new commercial capabilities in space may present NASA with new opportunities for private-public partnerships or may shift its R&D priorities.

The 2010 authorization act authorized funding increases for NASA that were not subsequently appropriated. In considering reauthorization, the 115th Congress may examine whether reduced budget expectations require corresponding changes to planned programs. One common concern is that the cost of planned human spaceflight activities may mean less funding for other NASA missions, such as unmanned science satellites, aeronautics research, and space technology development.

NASA's Earth Science program, in which climate research is a major focus, is of particular congressional interest. Some in Congress have argued that other NASA activities should have higher priority or that some or all of NASA's Earth Science responsibilities should be transferred to other agencies. Supporters counter that space-based Earth observations are an integral part of NASA's science mission.

For Further Information

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CRS In Focus IF10016, *Space Exploration*, by (name redacted)

Commercial Space

A survey by the Department of Commerce found that U.S. companies had $62.9 billion in space-related sales in 2012. While U.S. government purchases provided much of this market, about one quarter of sales were within the commercial sector.

Although the commercial space industry has existed for several decades, some observers have identified an emerging "new space" sector of relatively new companies focused on private spaceflight at low cost. One factor driving this trend is NASA's reliance on commercial providers for access to the ISS, but "new space" companies are also focused on other markets. These include the launch of national security satellites for the Department of Defense, the launch of commercial satellites for U.S. and foreign companies, and even space tourism.

The Federal Aviation Administration (FAA) licenses commercial space launch and reentry, including commercial spaceports. As part of the FAA licensing process, the federal government indemnifies launch providers against certain third-party liabilities. The U.S. Commercial Space Launch Competitiveness Act (P.L. 114-90) extended this indemnification policy (for the ninth time since 1988) through September 2025. The act also extended through September 2023 a

statutory moratorium that restricts the FAA's authority to regulate the safety of crewed spaceflight. The status of human spaceflight safety regulations has been a focus of recent congressional interest because of NASA's plans for commercial crewed flights to the ISS.

Several other federal agencies are also involved in the commercial space industry. The National Oceanographic and Atmospheric Administration (NOAA) licenses commercial remote sensing satellites. The Federal Communications Commission licenses the use of radio frequencies by commercial satellites and assigns locations for satellites in geostationary orbits. The National Transportation Safety Board investigates certain spacecraft accidents. The Department of Commerce Office of Space Commerce supports and promotes U.S. space commerce. Oversight of export controls on most aspects of commercial satellites shifted from the Department of State to the Department of Commerce in 2014. The 115th Congress may address coordination or simplification of these multiple agency roles.

For More Information

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CRS Report R44708, *Commercial Space Industry Launches a New Phase*, by (name redacted)

CRS In Focus IF10016, *Space Exploration*, by (name redacted)

Earth-Observing Satellites

The constellation of Earth-observing satellites launched and operated by the United States government performs a wide range of observational and data collecting activities, such as measuring the change in mass of polar ice sheets, wind speeds over the oceans, land cover change, as well as the more familiar daily measurements of key atmospheric parameters that enable modern weather forecasts and storm prediction. Satellite observations of the Earth's oceans and land surface help with short-term seasonal forecasts of El Niño and La Niña conditions, which are valuable to U.S. agriculture and commodity interests; identification of the location and size of wildfires, which can assist firefighting crews and mitigation activities; as well as long-term observational data of the global climate, which are used in predictive models that help assess the degree and magnitude of current and future climate change.

Congress continues to be interested in the performance of NASA, NOAA, and the U.S. Geological Survey in building and operating U.S. Earth-observing satellites. Congress has been particularly interested in the agencies meeting budgets and time schedules so that critical space-based observations are not missed due to delays and cost overruns. Concerns have been raised in Congress about the possibility of a "data gap" in the polar-orbiting weather satellite coverage. A near-term data gap could occur if the currently operating polar-orbiting weather satellite, the Suomi National Polar-orbiting Partnership (Suomi-NPP), fails before its successor, the first Joint Polar Satellite System (JPSS-1), is launched and operational sometime in 2017. JPSS-1 is designed to provide daily measurements from polar orbit that inform weather forecasts and storm predictions. The Government Accountability Office (GAO) has reported that a polar-orbiting weather satellite data gap would result in less accurate and timely weather forecasts and warnings of extreme weather events, which could endanger lives, property, and critical infrastructure.

On November 19, 2016, the GOES-R (Geostationary Operational Environmental Satellite-R) weather satellite launched and was placed into orbit. Now renamed GOES-16, it is the newest and most advanced weather satellite with sensors that should help improve hurricane tracking and intensity forecasts, prediction and warning of severe weather events, and rainfall estimates that will lead to better flood warnings. GOES-16 also carries the first operational lightning mapper in geostationary orbit, and will better monitor space weather—perturbations to the Earth's magnetic

field caused by intense bursts of energy from the sun. GOES-16 is the first of a series of satellites that are planned for geostationary orbit coverage through 2036.

For Further Information

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CRS Report R44335, *Minding the Data Gap: NOAA's Polar-Orbiting Weather Satellites and Strategies for Data Continuity*, by (name redacted)

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